Example 3b

June 17, 2020

1 Example 3b: Rotational trap - Analyzing experimental data with pretrained network

Example code to analyze experimental data with DeepCalib using a pretrained network.

DeepCalib 1.0 Enhanced force-field calibration via machine learning version 1.0 - 27 April 2020 l' Aykut Argun, Tobias Thalheim, Stefano Bo, Frank Cichos & Giovanni Volpe Soft Matter Lab

WARNING: THE PRETRAINED NETWORK IS NOT AVAILABLE FOR THIS EXAMPLE FILE DUE TO GITHUB's FILE SIZE LIMIT (100MB).
TO RUN THIS EXAMPLE FILE SMOOTHLY, PLEASE DOWNLOAD THE FULL PACKAGE FROM THE URL BELOW: https://ndownloader.figshare.com/files/23168663

1.1 1. INIZIALIZATION

```
In [1]: import DeepCalib
```

1.2 2. Import and visualize the experimental trajectory to be analyzed

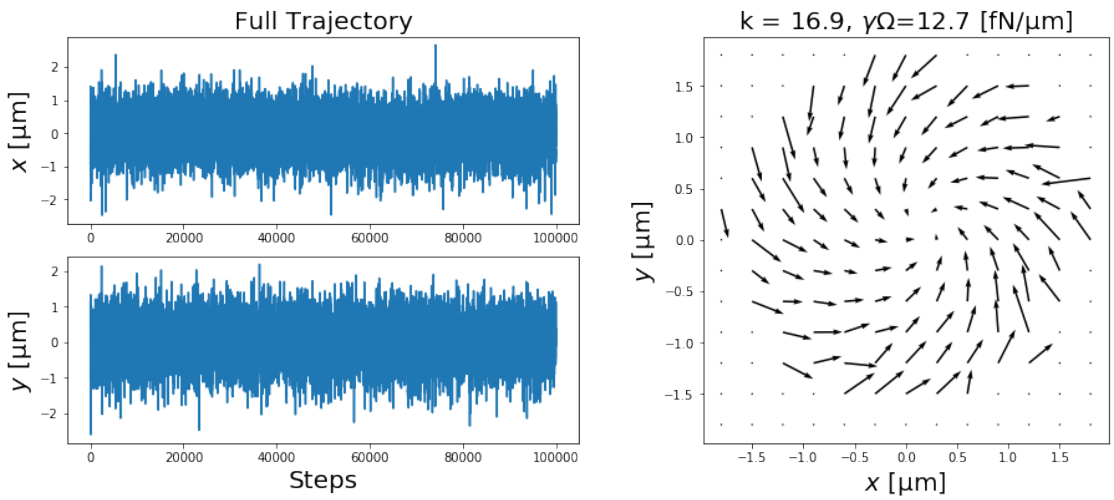
Here we import and visualize the experimental trajectory.

Comments: 1. Make sure you define the same scaling functions for the inputs and the targets the same in the training file.

```
In [2]: ### Import the data

        import scipy.io as sci
        data_name = 'Data_Example3b'
        x = sci.loadmat(data_name)['x'].reshape(100000,)
        y = sci.loadmat(data_name)['y'].reshape(100000,)

        ### Visualize the trajectory

        import matplotlib.pyplot as plt
        %matplotlib inline
        fig = plt.figure(figsize=(15, 6))
        gs = fig.add_gridspec(15,10)
        plt.subplot(gs[0:7,0:5])
        plt.ylabel('$x$ [\u03BCm]',fontsize=20)
        plt.title('Full Trajectory',fontsize=20)
```

```
plt.plot(x)
plt.subplot(gs[8:15,0:5])
plt.ylabel('$y$ [\u03BCm]',fontsize=20)
plt.xlabel('Steps',fontsize=20)
plt.plot(y)

### Evaluate the data

from numpy.linalg import inv
import numpy as np
r = np.array([x,y])[:,0:-1] *1e-6
f = np.diff([x,y])*6*1.4*np.pi*0.001*1e-13/1e-2
JF=np.matmul(np.matmul(inv(np.matmul(r,r.transpose())), r),
             f.transpose()).transpose()
m=-1/2*(JF[0,1]-JF[1,0])*1e9     # Measured rotational component by FORMA (fN / \mu m)
k=-1/2*(JF[0,0]+JF[0,0])*1e9     # Measured radial component by FORMA (fN / \mu m)
dx = np.diff(x);
dy = np.diff(y);
x = x[:-1]
y = y[:-1]
ux = np.zeros((13,13))
uy = np.zeros((13,13))
l = (np.arange(14)-7)*.3
for i in range(l.size-1):
    for j in range(l.size-1):
            ind = ( x<l[i+1] ) & ( x>l[i] ) & ( y<l[j+1] ) & ( y>l[j] )
            if sum(ind)>20:
                ux[j,i] = np.mean(dx[ind])
                uy[j,i] = np.mean(dy[ind])

### Visualize the measured truths

plt.subplot(gs[:,6:10])
plt.quiver(np.meshgrid(l[1:],l[1:])[0],
           np.meshgrid(l[1:],l[1:])[1],
           ux,
           uy)
plt.title('k = ' + str(np.round(k,1)) + ', ' + \
          '$\gamma \Omega$=' + str(np.round(m,1)) \
          +' [fN/\u03BCm]',fontsize=20)
plt.ylabel('$y$ [\u03BCm]',fontsize=20)
plt.xlabel('$x$ [\u03BCm]',fontsize=20)
```

Out[2]: Text(0.5, 0, 'x [m]')




```
In [5]: ### Analyze the data

        from keras.models import load_model
        import numpy as np
        from scipy.constants import Boltzmann as kB
        network = load_model('Network_Example_3a.h5')
        predictions_k = []
        predictions_m = []
        oversamp = 4
        nmeas = 100
        steps = int((x.size-1000*oversamp)/nmeas)
        slength = 1000*oversamp
        for i in range(nmeas):
            x_crop = [y[(i*steps):(i*steps+slength):oversamp],x[(i*steps):(i*steps+slength):over
            predicted_k, predicted_m = DeepCalib.predict(network, x_crop)[0]
            predictions_k.append(predicted_k)
            predictions_m.append(predicted_m)

        k0 = 2e-8                    # Reference stiffness [N m^-1]
        M0 = 2e-8                    # Reference rotational coefficient [N m^-1]
        rescale_targets = lambda scaled_k, scaled_m: [np.exp(scaled_k) * k0,
                                                   scaled_m*M0] # Inverse of targets_scaling

        [predictions_k, predictions_m] = rescale_targets(*np.array([predictions_k, predictions_m

In [6]: fig = plt.figure(figsize=(10, 5))
        plt.plot(predictions_k*1e9,'.')
        plt.plot([0, nmeas], np.array([1, 1])*k,color='black')
        plt.xlabel('Trajectory Segments',fontsize=20)
        plt.ylabel('Measured $k$ [fN / \u03BCm]',fontsize=20)
```

```
plt.ylim([0, 50])

fig = plt.figure(figsize=(10, 5))
plt.plot(predictions_m*1e9,'.')
plt.plot([0, nmeas], np.array([1, 1])*m,color='black')
plt.xlabel('Trajectory Segments',fontsize=20)
plt.ylabel('Measured $\gamma \Omega$ [fN / \u03BCm]',fontsize=20)
plt.ylim([0, 50])
```

Out[6]: (0, 50)